PAPERS

IN

AGRICULTURE.

No. I.

HEATING GREEN-HOUSES, &c.

BY HOT WATER.

The Thanks of the Society were presented to Mr. W. ANDERSON, Superintendent of the Company of Apothecaries' Botanic Garden, at Chelsea, for a communication respecting a cheap and simple method employed by him of Heating one of the Green-Houses by means of Hot Water.

As this is the first time that any communication has been published in the Society's Transactions on the employment of hot water for the purpose of warming green-houses, conservatories, and other buildings, the Committee of Correspondence and Papers, under whose superintendence these Transactions are published, have deemed it expedient to preface Mr. Anderson's communication by some general observations on the principles upon which the successful application of this method of warming depends, and on its advantages compared with other methods previously in use, particularly as applied to hot-

houses, conservatories, and other buildings for the preservation of tender plants.

When plants from warmer climates began to be cultivated in England, it was found necessary for their preservation during our long and cold winter, not only to afford them shelter, but also artificial warmth. The plan generally adopted for this purpose, was to carry a flue round the inside of the conservatory, through which the smoke and heated air from the fire passed, and consequently heated the flue, which warmed the interior of the conservatory by the heat which it gave off; the fire itself having no direct communication with the interior of the building, but being supplied with air and fuel from an opening on the outside. By this plan, a sufficient degree of heat may be communicated to the air in the interior of the conservatory; but if the fire is not properly regulated, the flue is liable to become over-heated, by which the plants in its immediate neighbourhood will be materially injured. The flue, by being over-heated, will also cause the air in the conservatory to become very dry, which will injure the health of many species of plants, by causing their moisture to evaporate too quickly. As the flue, even when only sufficiently heated, will have a tendency to render the air in the house dry, and as many species of plants preserved in hot-houses are natives of countries in which the air is very moist as well as hot, such plants will be liable to have their health injured, unless care is taken to keep the air sufficiently moist. In one of the houses in h Apothecaries' Garden at Chelsea, which is heated by a flue, Mr. Anderson places pans containing water on the top of the flue, to supply the air with the necessary degree of moisture. Sprinkling the floor and wall with water, whenever the air becomes too dry, has also been prac-

tised with considerable advantage.* Flues being usually composed of brick-work, and being exposed alternately to heat and cold, dryness and moisture, are, by their alternate expansion and contraction, very liable to crack and open in the joints of the brick-work, by which means some of the smoke and noxious vapours from the fuel escapes into the house, to the great injury of the plants; but even when great care is taken to prevent any cracks, it is probable that some of the noxious vapours will still find their way into the house through the pores of the brick-work.

In consequence of the inconvenience resulting from the use of flues, steam has been employed with considerable advantage for heating conservatories; and though some of the steam should escape out of the pipes into the house, from their joints becoming loose, it would probably be advantageous rather than injurious to the plants. Steam has also this advantage over hot water, that the pipes in which it is contained may sooner be raised to the required degree of heat, which may sometimes be of importance when a cold frosty night occurs suddenly and unexpectedly.

Water cannot be got up to the required degree of heat so soon as steam; yet, when once heated, takes a much longer time in cooling. If, therefore, during a long and cold winter's night, the fire of a steam-boiler, applied to warm a conservatory, should go out, the supply of steam would immediately cease, that portion already in the pipes would soon condense, and the plants would run great hazard of being injured by the cold before the fire could be re-lighted; but when water is used, there being a

* There is some valuable information on this subject in a paper by John Frederick Daniell, Esq., published in the sixth volume of the Horticultural Society's Transactions.

considerable quantity of hot water in circulation, the heat contained in it will most likely be sufficient to keep the house at a proper temperature during the remainder of the night.

The way in which heated water is commonly applied to warming hot-houses, is, by having a boiler at one end of the house, and a cistern at the other, the top of the boiler and the cistern being on the same level, but the bottom of the cistern should be a little above that of the boiler; a horizontal pipe passes from the top of the boiler to the top of the cistern; another pipe passes from the bottom of the cistern, inclining a little downwards to the bottom of the boiler. The fire being lighted under the boiler, so soon as the water in the boiler begins to get warm, it flows along the upper pipe from the top of the boiler to the top of the cistern, and at the same time cold water flows along the lower pipe from the bottom of the cistern to the bottom of the boiler. The water receiving heat in the boiler, and parting with it in the pipes and cistern, the circulation of water will continue as long as the fire is burning, and for some time longer, or until the water in the boiler is cooled down to the same temperature as that in the cistern; for, the circulation depending on the difference of temperature, and consequently of specific gravity, between the water in the boiler and that in the cistern, the effect will be produced as long as the cause continues. The lower pipe is made to incline a little downwards towards the boiler, to facilitate the return of the cold water to the bottom of the boiler, and also to prevent any air lodging in the pipe, which would much impede the circulation.

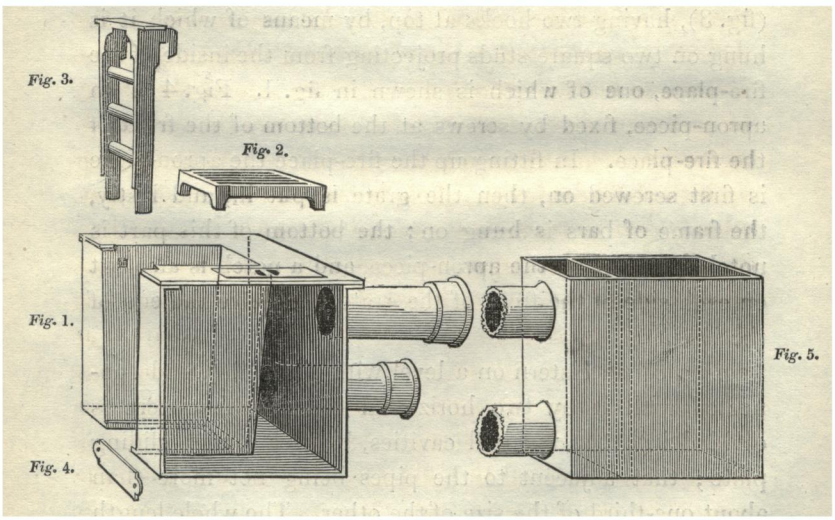
This being the simplest plan upon which an apparatus can be constructed for warming by the circulation of hot water, is the one generally adopted, not only in hot-

houses, but in all cases where the apartments to be warmed are all on the same level, or nearly so. The cistern is not necessary, as far as the circulation merely is concerned, as that would be carried on just as well by a pipe forming a communication between the upper and the lower pipe; but the cistern is useful in collecting a body of warm water at that end of the house which is the farthest from the boiler, and which, consequently, would otherwise be the coldest. The greater the quantity of water in circulation, the longer will be the time which it will take to bring it up to the required temperature, other circumstances being the same; but the longer also will be the time which it will retain its heat. By putting a small quantity of water in circulation at first, and afterwards increasing the quantity, the advantages of getting the heat up quickly, and of retaining it for a considerable time, may both be obtained. A simple method of accomplishing this object is described in Mr. Anderson's communication. The cast-iron pipes used by the water-companies are those commonly used for the circulation of hot water; and they are very well adapted to the purpose, being cheap, good conductors of heat, and the surface, being rough and of a dark colour, is well adapted for the radiation of heat. As the iron pipes will be expanded by heat, and contracted by cold, they will be liable to become loose, and to leak in the joints. A small leakage in a hot-house would not be of much consequence; but in a sitting-room or a shop it would be attended with great inconvenience, and consequently it is of great importance to guard against it: the pipes and cistern ought therefore not to be immovably fixed, but only supported in such a way as will allow them to move freely with the expansion and contraction of the pipes: where the pipes

are of considerable length, and the cistern heavy, it should be placed on wheels or rollers. Hot water may be made to circulate to a considerable height above the boiler, so as to warm the whole of a house from a boiler placed in the lower story. The boiler must be closed at top, and the pipe must be open at the highest point. The pipe should have a constant inclination upwards from the top of the boiler to the highest point, and a constant inclination downwards from the highest point to the bottom of the boiler; at all events, it should never go up, and then down, and then up again, as that would very much impede, if not altogether stop, the circulation. Though the water will circulate above the boiler, it will not circulate to any considerable depth below the boiler, except some mechanical force is employed to give it motion. A patent has lately been taken out to make the hot water circulate below the fire by means of flyers made to revolve horizontally in the boiler, motion being communicated to them by a fly-wheel placed in the chimney, similar to the flyerof a smoke-jack; the water being forced out of the boiler into a pipe through a hole in the side of the boiler, by means of the centrifugal force caused by the revolution of the flyers, and returning through a pipe communicating with the boiler through a hole in the centre of its bottom. Should this contrivance answer as well when brought into actual use, upon a large scale, as it did in the experiments made with it upon a small one, it may perhaps serve to extend the use of warming by means of the circulation of hot water to cases in which it could not before be conveniently applied. Persons desirous of obtaining farther information on the application of hot water to warming green-houses and other buildings, may consult with advantage a paper by the late Mr. Tredgold, in the 7th

volume of the Transactions of the Horticultural Society, particularly as to the relative proportions between the buildings required to be warmed, and the boiler and pipes to be employed for that purpose; also, an account of a plan for heating stoves by means of hot water, communicated to the Horticultural Society by Mr. William Whale, gardener to Anthony Bacon, Esq. and published at page 203, vol. vii. of their Transactions.

At the back of one of the green-houses in the botanic garden belonging to the Company of Apothecaries, is a room which serves the gardeners as a sitting-room and kitchen. It struck Mr. Anderson that part of the heat produced in the fire-place of this room might, without inconvenience, be employed to warm the green-house, by connecting with it a hot-water apparatus.



For this purpose, a boiler of iron (fig. 1) was cast all in one piece (except the top plate), having an open recess in front; two short pipes, also of one piece with the boiler, project horizontally behind. These pipes are enlarged at the end to receive the plain ends of other pipes, and allow of their being accurately cemented together, so as to be water-tight. The recess, or fire-place, is 10 inches high, 11 inches wide at top, and gradually narrows to 9 inches at bottom; it is 8 inches deep at top, and not quite so much at bottom. The distance between the three sides of the fire-place, and the corresponding exterior sides of the boiler, is about five inches, the intermediate space forming the cavity in which the water is contained. The bore of the pipes is $3\frac{1}{2}$ inches. The top plate is secured to the boiler by screws, and has in it a man-hole, also fitted with a steam-tight cover. Round the bottom of the fire-place is a horizontal ledge, on which rest the feet of the grate (fig. 2). The front bars are connected together in a frame (fig. 3), having two hooks at top, by means of which it is hung on two square studs projecting from the inside of the fire-place, one of which is shewn in fig. 1. Fig. 4 is an apron-piece, fixed by screws at the bottom of the front of the fire-place. In fitting up the fire-place the apron-piece is first screwed on, then the grate is put in, and lastly, the frame of bars is hung on; the bottom of this part is notched to rest on the apron-piece, and a notch is also cut on each side of the front of the grate to receive the end of the bars.

Fig. 5 is a cistern on a level with the boiler, and connected with it by two horizontal pipes: the cistern is divided into two unequal cavities, by means of a sliding plate; that adjacent to the pipes being not more than about one-third of the size of the other. The whole length

of the green-house is 57 feet; but as the pipes enter about the middle of the back wall, and the cistern is placed near one end of the house, only half of it is heated by direct radiation from the pipes, the other half being appropriated to those plants that require a smaller supply of artificial heat.

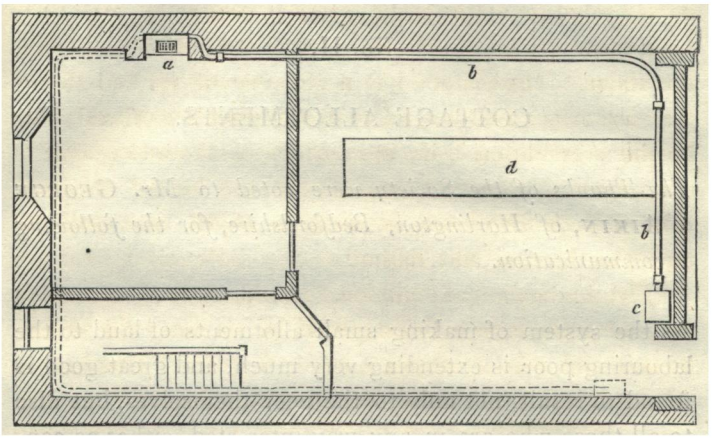
The boiler, pipes, and cistern, being filled with cold water, and the sliding partition of this latter being put down, the fire is lighted. Immediately, an ascending current of hot, and therefore expanded water, is established adjacent to the sides of the fire-place, and a quantity of cold water, equal to the expansion of the warm water in the boiler, is forced through the upper pipe into the cistern; the column of water in the cistern becomes somewhat longer than that in the boiler, and also is of greater specific gravity in proportion to its lower temperature: the result of this is, that the hydrostatic pressure of the column contained in the cistern is greater than that of the column in the boiler, in consequence of which the cold water will press into the boiler through the lower pipe, while the hot water will be forced though the upper pipe into the cistern with a velocity proportioned to the difference of hydrostatic pressure of the two columns. As the warm water passes along the upper pipe, it is continually giving out heat to the surrounding air; and if, when it reached the cistern, it had cooled down to the temperature of the water already there, the partition would be of no use; but as, on the contrary, the temperature of the water flowing in is considerably higher, and as it is desirable that the upper pipe should be brought to its full heat as soon as possible after lighting the fire, there is an advantage in keeping out of the circulation the greater part of the cold water in the cistern till the hot pipe has got

completely into action ; the reserved cold water may then be brought gradually into the general circulation by raising the slider. The cistern has a movable cover, and therefore not only serves the purpose of a reservoir of heat, but, by the evaporation from the surface of the water, affords the requisite degree of moisture to the heated air ; and this may be regulated by putting on or removing the cover, as the case may require.

Mr. Anderson is of opinion, that the above contrivance may be advantageously employed in warming the greenhouses and conservatories now so frequently attached to sitting-rooms and staircases ; for, being generally very small, the cold soon penetrates them, while, at the same time, it is hardly worth while to appropriate a stove to their sole use, nor indeed will their situation often allow of it, even if the cost were no objection.

In very severe weather, Mr. Anderson employs in aid of the hot water apparatus a lining of mats, hung as near the glass as convenient ; having found by experience that it is far more advantageous to retard the contact of the warm air with the cold glass, than to attempt to keep in the warmth by the application of mats, or any other bad conductor of heat, on the outside.

A similar plan might probably be adopted for heating shops from the fire in the adjacent little parlour or back shop. The accompanying figure represents such an arrangement, in which *a* is the fire-place, having the sides and back surrounded by the boiler, *b b* the upper pipe, first passing along the wall of the shop, then turning at right angles below the window, and terminating in the cistern *c*. The return-pipe being of the same figure as the upper one, and situated directly below it, is not shewn ; *d* the counter.



As heat expands metals, though in a small degree, yet with a force quite irresistible, it is evident that means must be taken to obviate the leakage which is liable to take place at the junctures of the pipes from this alternate expansion and contraction. If the pipes form a right line from the boiler to the cistern, the object will be attained by setting the cistern on rollers, with the allowance of an inch or two for their forward and backward motion; but if the pipes make a bend or elbow, as represented in the preceding figure, the spring or elasticity of the material will be sufficient of itself to prevent damage.